

Release 5 SESAR Solution #101
Extended hybrid surveillance

Contextual note – SESAR Solution description form for deployment planning

Purpose:

This contextual note introduces a SESAR Solution (for which maturity has been assessed as sufficient to support a decision for industrialization) with a summary of the results stemming from R&D activities contributing to deliver it. It provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution in terms of scope, main operational and performance benefits, relevant system impacts as well as additional activities to be conducted during the industrialization phase or as part of deployment. This contextual note complements the technical data pack comprising the SESAR deliverables required for further industrialization/deployment.

Improvements in Air Traffic Management (ATM)

The SESAR Solution “Extended hybrid surveillance” refers to enhancement of TCAS (Traffic Collision Avoidance System) II surveillance capability. This enhancement is based on adding the Extended Hybrid Surveillance to hybrid and original active surveillance of TCAS II. The new passive methods allow tracking distant intruders with very limited frequency of Mode S interrogations (hybrid surveillance) or even with no interrogations at all (Extended Hybrid Surveillance).

Passive tracks are built using ADS-B (Automatic Dependent Surveillance – Broadcast) version 2 reports from qualified intruders. The two passive methods differ in the way how ADS-B data quality is assessed:

- Hybrid surveillance relies on active Mode S interrogations and cross-check (position validation) of the active and passive positions.
- Extended Hybrid Surveillance uses the quality parameters included in the ADS-B reports.

For Extended Hybrid Surveillance, there is also a safety barrier implemented by signal strength monitoring. Signal strength higher than a predefined threshold could be a sign of close distance of the emitting aircraft. Such an intruder is switched under hybrid surveillance and thus becomes subject to position validation.

Other conditions that govern transitions between surveillance methods include: ownship and ADS-B data availability and quality; distance and predicted trajectory of the intruder; and position validation results.

TCAS II (without the enhancement brought by Extended Hybrid Surveillance) is exclusively dependent on 1090 MHz replies that are elicited by its 1030 MHz interrogations. These replies provide relative distance, relative bearing and aircraft altitude of the intruder and are used to build active tracks. However, measurements suggest that TCAS is one of the biggest consumers of the 1090 MHz link. Other applications that depend on the same communication channel are secondary surveillance radar (SSR) and ADS-B. As air traffic increases, overload of the 1090 MHz link is a concern for the future Air Traffic Management

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system. It could lead to deterioration of surveillance reliability with impact on both safety and efficiency.

Allowing TCAS to perform surveillance using position and velocity data obtained from ADS-B reports and own navigation sensors was thus a logical possibility to decrease the 1090 MHz channel usage.

Extended Hybrid Surveillance was developed to operate in the same environments as TCAS II, including surface operations, where the specific transition logic is applied. When ownship operates on ground, extended hybrid surveillance can be applied to qualified intruders regardless of their proximity. Busy airports will thus benefit from this feature significantly.

Operational Improvement Steps (OIs) & Enablers

The technological solution covers the enabler **A/C-54a**: Enhanced Airborne Collision Avoidance (ACAS) and will support OI steps **CM-0808-a**: Improved Collision Avoidance for commercial air transport in standard operations (ACAS Xa) and CM-0808-u: Collision Avoidance for remotely piloted aircraft.

Applicable Integrated Roadmap dataset is DS15. Currently, there is a pending change request to better define the enabler dedicated to Extended Hybrid Surveillance. Its proposed name is A/C-54a-rai (rai stands for reduced active surveillance).

Background and validation process

The SESAR Solution was validated in three steps:

- The TCAS II with Extended Hybrid Surveillance capability (developed by Honeywell) was integrated in Airbus lab with roof-top antenna installation in proximity of Toulouse airport. Traffic in this area was tracked and the behaviour of the system was evaluated off-line. This validation exercise showed seamless basic functionality.
- The TCAS II with Extended Hybrid Surveillance capability was installed in Airbus test aircraft and used for several flight tests during which the tracking of surrounding traffic was recorded. These were the first worldwide flight tests of this SESAR Technical Solution. Real traffic recordings were crucial for both validation and benefit analyses as well as input for the third step (below).
- The results obtained during the previous validation activities were extrapolated to behaviour in core European airspace. EUROCONTROL simulation was used to evaluate the overall impact on 1090 MHz load in this area.

There is very small percentage of traffic equipped with ADS-B Out version 2 in Europe nowadays. Therefore legacy ADS-B reports (versions 0 and 1) with sufficient reported quality were also allowed for this validation activity. Passive tracking worked according to expectations even for such targets.

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Results and performance achievements

The main findings from the overall validation exercises can be summarised as follows:

- The system behaved as expected both in the air and on surface.
- The proposed signal threshold value for transition between hybrid and extended hybrid surveillance were both safe and efficient.
- Passive acquisition is used in majority of the intended situations.
- Air/ground transition of own ship surveillance logic is handled correctly.
- There were no disturbing oscillations (i.e. transitions backwards and forwards) between surveillance methods.
- Transitions to active surveillance are made sufficiently in advance before Traffic Advisory and Resolution Advisory.
- The maturity of the developed minimum operations system requirements (MOPS) was confirmed at TRL (Technical Readiness Level) 6. Only a few minor technical comments were communicated to the standardization working group.
- TCAS II update to TCAS with Extended Hybrid Surveillance does not change the TCAS experience (same TAs and RAs) for the airspace users (pilots, ATC).

Another objective was to compare the 1090 MHz link usage with the SESAR Technical Solution compared to the reference system (i.e. TCAS II). The preliminary benefit assessment was based on real measurements of active interrogations for tracked qualified intruders. “What-if analysis” was then used to derive the necessary interrogations for TCAS II in the same traffic situations. This first assessment showed reduction of Mode S interrogations by more than 70 %.

A refined benefit analysis taking into account additional factors (broader set of environment types, acquisition interrogations, dormancy interrogations and unsuccessful interrogation attempts without reply) showed approximately 82 % savings.

Benefit analyses results were supported by the outcome of European traffic simulations.

These results indicated that Extended Hybrid Surveillance is a very promising and important tool for reduction of 1090 MHz load.

Recommendations and Additional activities

Extended hybrid surveillance capability is required by FAA for any future certifications (based on TSO-C119d) in USA.

As the significant benefits of Extended Hybrid Surveillance do not directly reduce airline costs, the mechanism to motivate airspace users to equip should be defined as a potential additional activity.

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Actors impacted by the SESAR Solution

Reduced load of 1030/1090 MHz frequency has an impact on the following actors:

Air Traffic Services Operations – **Executive Controller (ATC)**, who is responsible for the safe and expeditious flow of all flights operating within his area of responsibility, may benefit from decreased risk of radar information loss due to overloaded frequency band, and thus from better quality of provided information.

In the same way, observed benefits impact Airspace User Operations – Aircraft Operator – **Flight Crew (Pilot)**, who is responsible for safe and orderly operation of the flight in compliance with the ICAO Rules of the Air, other relevant ICAO and CAA/EASA provisions, and within the standard operating procedures.

Impact on Aircraft System

System impact can be split into two types of requirements:

1. Requirements related to **ADS-B In capability**, i.e., the capability to receive and process ADS-B reports from surrounding a/c
 - When ADS B In hosted in TCAS, wiring between TCAS and GNSS source (GNSS source required already for ADS-B Out mandate so it is not considered as a new requirement).
 - ADS B In processing according DO-260B/ED-102A (only a subset specified in DO-300A/ED-221 is really required for Extended Hybrid Surveillance)
2. **TCAS II SW update addressing tracking and surveillance**
 - Implementing the use of ADS-B information for ACAS tracking in the extent specified within DO-300A/ED-221

In addition the US advisory circular AC 20-151B requires that “failures of hybrid surveillance must be annunciated to the flight crew or the continued airworthiness must be assessed during periodic scheduled maintenance tasks”. In practice this will involve an indication when own GNSS data is not available.

The final a/c impact therefore differs depending whether ADS-B In capability (as required by DO-317B/ED-194A applications) is already installed or not.

- For ADS-B In capable a/c only the TCAS II SW update (2) is needed.
- For a/c without ADS-B In capability both (1) and (2) set of requirements are needed, although the costs for (1) may be shared with possible implementation of ADS-B In applications. In the case that only Extended Hybrid Surveillance is required only a limited ADS-B In processing may be implemented (as specified in DO-300A/ED-221).

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Impact on Ground Systems

This SESAR Solution has no impact on Ground systems.

Regulatory Framework Considerations

1090 MHz frequency load should be monitored as any congestion would result in serious safety and capacity issues that cannot be fixed immediately. As soon as congestion is anticipated, mitigation measures should be applied. From an operational perspective Extended Hybrid Surveillance is probably the most cost effective option to address the issue. Depending on the urgency and target impact of corrective actions, SES and EASA should determine the appropriate deployment method: encourage equipment (e.g. using incentives) or require aircraft equipage by application of an implementing rule for forward fit or even for retrofit.

Standardization Framework Considerations

Hybrid surveillance was first standardized in 2009 in the USA but the original version was modified and extended hybrid surveillance was added in 2013 when the MOPS RTCA DO-300A/EUROCAE ED-221 were published by the RTCA SC-147/EUROCAE WG-75.

Considerations of Regulatory Oversight and Certification Activities

For the regulatory oversight, two facts should be taken into account:

- Minimum Operational Performance Standards (MOPS) for Extended Hybrid Surveillance has been already published both by EUROCAE (ED-221) and RTCA (DO-300A).
- Extended Hybrid Surveillance, as specified in DO-300A/ED-221, is required by FAA in the current version of Technical Standard Order, i.e. TSO-C119d.

Solution Data pack

The Data pack for this Solution includes the following documents:

- **TS:** Performance objectives and functional requirements for the use of Improved Hybrid Surveillance in European environment (9.47 - D10, v.00.00.01, November 2012). This document provides description of the proposed TCAS enhancements in terms of functional requirements, and it was a baseline for development and validation of Extended Hybrid Surveillance capability in SESAR 9.47 project.

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- **VALR:** Report on Improved Hybrid Surveillance validation – issue 2 (9.47 – D32, v.00.02.00, February 2015). This document concludes all SESAR 9.47 validation activities of TCAS II with improved hybrid surveillance capability and provides feedback to the standardization activities on the extended hybrid surveillance MOPS.

Additionally, standard **DO-300A/ED-221** describing minimum operational performance requirements should be used as reference, however this document should be obtained via RTCA/EUROCAE.

Intellectual Property Rights (foreground)

The foreground is owned by the SJU.